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Abstract

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Keywords

sendzimir, mill, fem, pressure, gap, roll, analysis

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Analysis of Roll Gap Pressure in Sendzimir Mill by FEM

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Abstract: The acting force on the roll system of Sendzimir mill was analyzed using 3D FEM. The roll gap pressure distribution and the acting force between rolls S and O, rolls O and I, rolls O and J, rolls I and A, rolls I and B, as well as rolls J and B were analyzed. The results showed that the roll gap pressure mainly affected the roll surface layer, 50 mm for backup roll; the roll gap pressure distribution is of double peaks among the work roll, the 1st intermediate roll (IMR), and the 2nd IMR; the maximum value of the roll gap pressure between the backup roll and the second IMR appears on the edge of the barrel of rolls; the component force presents the in-para-curve distribution. These are important for reducing the wear of rolls and the break of the backup roll and guiding for production.
Key words: roll gap pressure; Sendzimir mill; FEM

The main characteristics of 20-high Sendzimir mill are the small diameter of the work roll, great rigidity of the roll system, big pass reduction, and high accuracy of the product. It is widely used to produce the stainless steel strip, silicon strip, high-accuracy thin strip, non-ferrous strip, etc. At present, there are mainly two kinds of Sendzimir mills, one with a single AS-U-Roll system and the other with a double AS-U-Roll system (Fig. 1), which consists of backup rolls A to H, the 2nd intermediate rolls (IMR) I to N, the 1st IMR O to R, and work rolls S to T.

Some researches[1-6] were carried out on the rolling process of the Sendzimir mill, such as the roll-stack deflection, the strip profile. There are several contacts in the roll system, which affect the pressure distribution on rolls, and then affect the shape control of the strip. LIU Xiang[7] and PAN Chun-jiu[8] analyzed the acting force on the rolls. However, there are no research reports about the roll gap distribution of Sendzimir mill with the double AS-U-Roll system.

FEM is widely used to analyze the rolling process. Researchers[9] analyzed the rolling pressure distribution in a plane view pattern controlling pass of plate rolling. LIU Li-zhong et al[10] studied the double-peak distribution of the pressure in plate rolling. XIE Hong-biao et al[11] researched the rolling pressure distribution of strip with different reduction. However, until now, there is no research report concerning the roll gap pressure.

In this study, the acting force on the rolls of a Sendzimir mill was simulated using 3D FEM, and the roll gap pressure distribution and the acting force

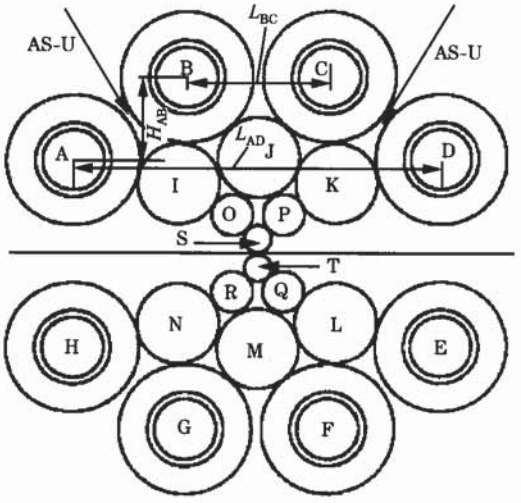

Fig. 1 Sendzimir mill with double AS-U-Roll system

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between contacting rolls were analyzed. Also, the acting force on each roll body was analyzed, which is important for reducing the wear of rolls and the break of the backup roll and guiding for production.

1 Finite Element Model

In this study, FEM is used to simulate and analyze the upper part of the roll system in Sendzimir mill, and the geometrical parameters of the roll system, the rolls, and the physical properties of the material of the roll are listed in Table 1.

The backup roll, consisting of six different roll bodies, is shown in Fig. 2. Each roll body is connected to the AS-U racks, which are used to control the shape of the rolled piece.

Finite element model of the upper half of the roll system was established according to the parameters as shown in Table 1. The parts of AS-U racks in the backup roll were assumed to be rigid and were constrained as: $U_x = U_y = U_z = 0$, where U is displacement constrained. The remaining parts were assumed to be elastic bodies. The model of the whole system was dispersed with 8-node and hexahedral elements, and the elements near contact position were refined. Meanwhile, there were totally 42 pair contact positions between rolls. The geometrical model and grids for the whole roll system is shown in Fig. 3, and the rolling force is loaded on the bottom of the work roll.

Table 1 Geometrical parameters and calculation conditions

Parameter	Value
Diameter of roll S/mm	65
Diameter of rolls O and P/mm	133
Diameter of rolls I, J, and K/mm	230
Diameter of rolls A, B, C, and D/mm	406.4
Barrel length of rolls/mm	1 346
Distance between center of rolls A and D (L_{AD})/mm	1 086
Distance between center of rolls B and C (L_{BC})/mm	415
Direct distance between center of rolls A and B (H_{AB})/mm	241.7
Width of strip/mm	1 036
Space length on backup roll (W)/mm	64
Length of part of backup roll (L)/mm	171
Density/(kg · m^{-3})	7 850
Young's modulus/GPa	220
Poisson's ratio	0.3

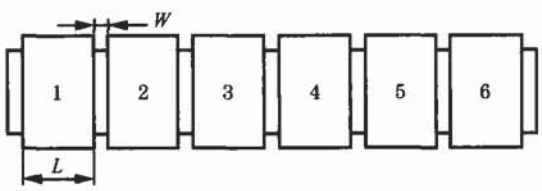

Fig. 2 Simplified model of backup roll

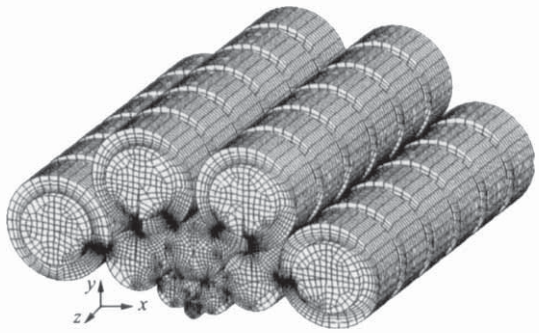

Fig. 3 Geometry and meshing of roll system in Sendzimir mill

2 Results and Discussion

2.1 Acting force on rolls

The equivalent stress distribution acting on the backup roll is shown in Fig. 4 (a). Owing to the assumed line contact between the rolls and the high hardness of the rolls, the stress is distributed mainly on the surface of the rolls. Fig. 4 (b) shows the analysis of the stress distribution in one section of the third length, from which it can be found that the pressure mainly affects the rolls' surface layer with about 50 mm thickness.

Consider that the backup roll of the Sendzimir mill consists of shaft, inner (outer) eccentric ring, needle bearing, backer bearing, and so on, and the needle bearing and the backer bearing are vulnerable; then, the analysis of pressure distribution on the backup roll is important for choosing these bearings and raising their lifetime.

2.2 Roll gap pressure

As the roll system is symmetrical, the contact pressures between rolls S and O, rolls I and O, rolls J and O, rolls A and I, rolls B and I, as well as rolls B and J are analyzed.

The roll gap pressure distribution between rolls S and O, rolls O and I, rolls O and J is shown in Fig. 5 (a). It can be seen that the roll gap pressure is of double peaks and the maximum value appears on the edge of barrel of rolls. Fig. 5 (b) shows the roll gap pressure distribution between rolls A and I, rolls B and I, rolls B and J, where the space parts are the AS-U racks position, and there is no contact between the rolls. As each body of the backup roll is constrained by the AS-U rack, the maximum value of pressure appears on the edge of the barrel of rolls.

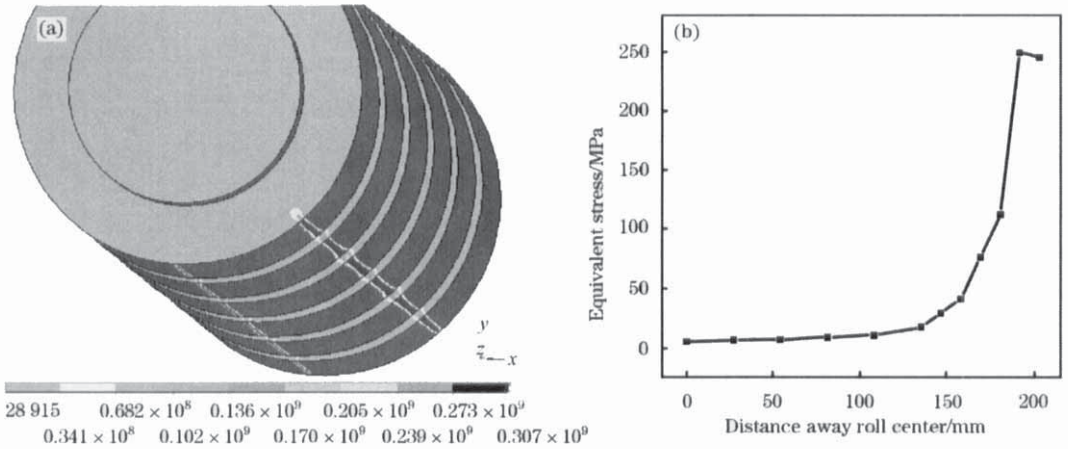

Fig. 4　Roll gap pressure distribution on roll B

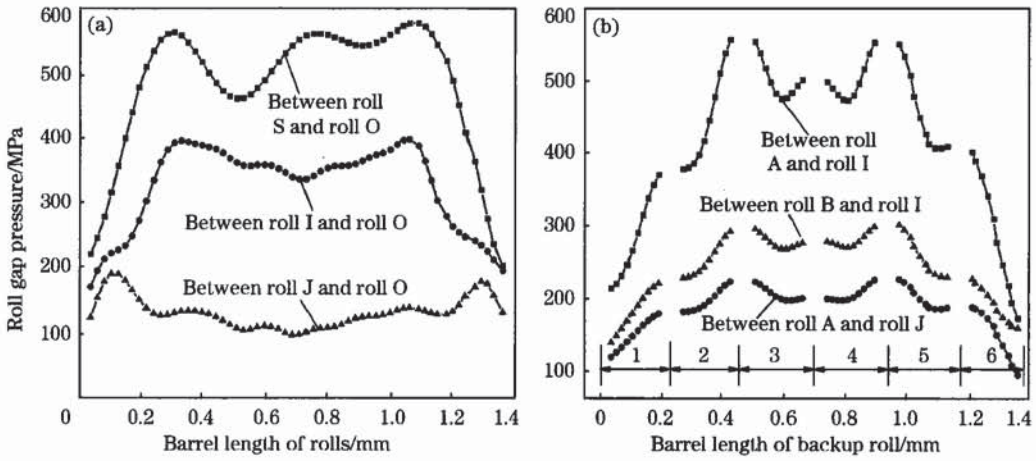

Fig. 5　Roll gap pressure distribution

It can be found by comparing Fig. 5 (a) with Fig. 5 (b) that the roll gap pressure on the side of the roll system is higher than that on the other parts.

All the above results are helpful in reducing the wear of rolls and for controlling the shape. These are also important for preventing the needle bearing from damage since the contact pressure varies with the regulating bar move.

During the rolling process, the roll gap pressure will affect the strip profile and the edge drop. The strip shape and the edge drop can be controlled by adjusting the roll gap pressure distribution. In Fig. 5, the value of the roll gap pressure between rolls S and O, rolls I and O, rolls A and I is considerably larger than the rest. Thus, the effect of adjusting the roll gap pressure between rolls A and I for controlling the strip shape will be better than that between rolls B and J. When compared with the Sendzimir mill with a single AS-U-Roll system, the Sendzimir mill with a double AS-U-Roll system will have more power for controlling the strip shape and the edge drop.

2.3　Force of roll system

The force of the roll system under the given conditions is shown in Fig. 6; Fig. 6 (a) shows the contact force between rolls S and O (PA), O and I (PB), O and J (PC), and Fig. 6 (b) shows the contact pressure between the backup roll and the 2nd IMR. It can be seen that the contact force between rolls S and O (PA), O and I (PB), and I and A are higher than the rest. At the same time, Fig. 6 shows the component forces between the backup roll and 2MR, which presents the in-para-curve distribution.

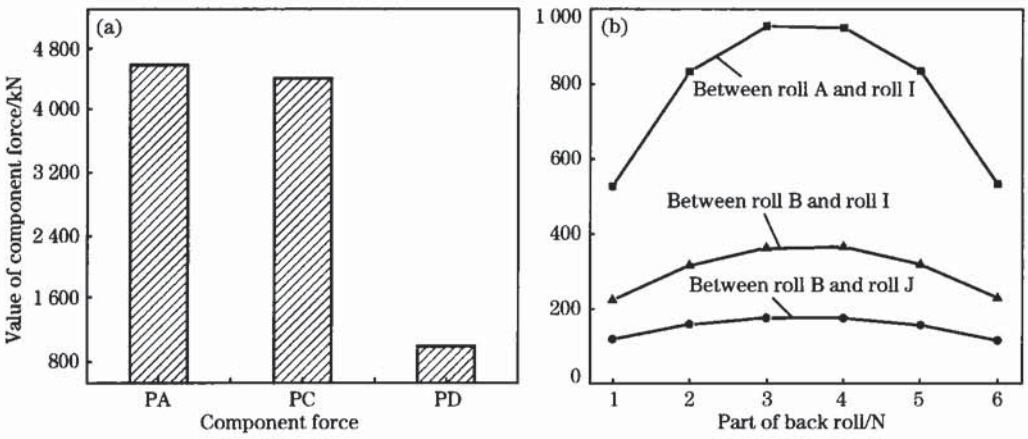

Fig. 6 Component force of roll system

3 Conclusions

(1) The roll gap pressure mainly affects the surface layer of the roll which has a thickness of about 50 mm for the backup roll.

(2) The roll gap pressure is of double peaks among the work roll, the first intermediate roll (1st IMR), and the second intermediate roll (2nd IMR), and the maximum value between the backup roll and 2MR appears on the edge of the barrel of rolls.

(3) The roll gap pressure on the side of the roll-system is higher than that on other parts, and the component force presents the in-para-curve distribution.

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